though micas generally give lower values than the true on account of their crystal habit. For example, Lepidolite 2.9 (2.8–2.9), biotite 2.9 (2.7–3.1), muscovite 3. (2. 76–3.), phlogopite 2.9 (2.78–2.85).

In spite of these slight deviations, which undermine one's faith in the accuracy of the book, there is little doubt that the tables will prove serviceable to the practical worker who wishes to gain at a glance the approximate values of the substance under investigation.

The typography of the book is good, the type is clear, and the matter is well spaced. An especially attractive feature is the size, which is adapted to the collecting bag or pocket. The few instruments required, the use of the external and physical properties only, the notes on the paragenesis, and the great number of rarer minerals, will make it serviceable alike to the field geologist, the mining engineer and the teacher.

E. B. MATHEWS.

Traité élémentaire de mécanique chimique, fondée sur la thermodynamique. P. DUHEM. Paris, A. Hermann. 1897. Vol. I. Large octavo. Pp. viii+299. Price, 10 francs.

The object of this book is to give a consistent, coherent account of the mathematical theory of the changes in physical state and chemical constitution, as obtained by an application of thermodynamics. This would be valuable even if badly done, since the mathematical treatment of physical chemistry in book form is painfully deficient in comparison with the exhaustive handling of the experimental side of the subject by Ostwald. This particular book is doubly valuable because it not only gives us the mathematical development of the subject, but presents it in a masterly way.

Duhem begins with a short sketch of the analytical methods to be used, and then develops the fundamental principles of thermodynamics, taking up in order the conservation of energy, the first law of thermochemistry, the theorem of Carnot-Clausius and the absolute temperature, the entropy and the thermodynamic potential, the general equations of thermodynamics, the application of the thermodynamic potential to systems at constant pressure or constant volume, perfect gases, isothermal displacement of equilibrium, heat effects, adiabatic displacement of equilibrium and the change of the equilibrium with the temperature. The remarks on the accuracy of Hess's law, page 49, are especially worth reading because the points raised are usually overlooked in the statement of the theorem.

The second part of the volume—devoted to false equilibria and explosions—is even more interesting than the first part because the point of view is less familiar. Duhem has been troubled like many others by the fact that in certain cases there was a state of equilibrium when the theory, as formulated, said that this was impossible. Gibbs showed that many of the difficulties could be removed by the assumption that the surface of a phase was in a different state from the interior—in other words, by the theory of capillarity. Duhem attempts to carry this farther by introducing the notion of viscosity or of false equilibrium. His idea can best be understood by an analogy from mechanics. Suppose we have a body on an inclined plane. In an ideal state of things where there is no friction the body is not in equilibrium and will slide down the inclined plane. In the world as it is we can not get rid of friction entirely and the body will remain stationary on the plane, provided the pitch is not too great. Similarly, if there were no passive resistance to change, water vapor and a mixture of hydrogen and oxygen in the proportions in which they combine to form water should yield the same system under the same conditions. At low temperatures this is not the case experimentally, so far as we now know; so that it is natural to follow out the analogy and to say that in the actual chemical world there is a chemical friction or chemical viscosity and that states of equilibrium are thus possible which could not occur in a system where there were no passive resistances to change.

Duhem now attributes to capillary phenomena the behavior of supercooled vapors and superheated liquids, and he is inclined to group under this head supercooled solutions, supersaturated solutions and some theoretically unstable solid allotropic forms, classifying under false equilibria hydrogen and oxygen, liquid

phosphorus, silicon trichlorid and many other substances. It is a question whether this is justifiable. It seems irrational to put rhombic and monoclinic sulphur in one class and the two modifications of phosphorus in another; but it is certainly interesting, and the application of his theory to the point of reaction, to reaction velocities and to explosions deserves careful attention. It will interest many to note that Duhem's view of a mixture of hydrogen and oxygen as being actually in equilibrium at low temperatures is not reconcilable with the Ostwald-Nernst idea that it is not a case of equilibrium at all, but rather of immeasurably low reaction velocity. A fairly strong argument can be made out for either view, and the scientific world owes thanks to Duhem for making the question a live one.

WILDER D. BANCROFT.

Trigonometry for Beginners. REV. J. B. LOCK, M. A. Revised and enlarged by JOHN A. MILLER, A. M., Indiana University. New York, The Macmillan Company. 1896. 200 pp. Price, $1.10.

Trigonometry, of all elementary branches of mathematics, might easily substantiate its right to be considered the most congenial and popular subject that necessarily claims the attention of engineers and practical men, otherwise but little inclined to sympathize with the purest in the science. Led on by its numerous and interesting applications, many a student, without being aware of it, has taken his first step in the theory of functions, acknowledged the results to be fascinating as well as eminently practical, and gone his way to rail at the higher theory, quite unconscious of the spectacle he thereby makes of himself. The natural result of this favoritism has been a steady improvement in the quality of the text-books produced in trigonometry until such works as that of Chauvenet and, to mention a less ambitious book, that of Wells, challenge competition successfully for a series of years.

With a new edition of Lock's Trigonometry, The Macmillan Company enters the field, and with its usual business sagacity have secured its revision by an American. Professor Miller has certainly earned the right to have his name on the cover, indeed, because of additions and improvements far less necessary and fundamental many a man would have called the volume his own. As claimed, the new edition corrects the fundamental weakness of its predecessor by carefully emphasizing the necessity for proofs for all relations, especially for the addition formula, that are rigidly correct for all values of the angles involved. To this end, as is necessary, we find clear demonstrations of such relations as, for example, $\sin(90° + A) = \cos A$ for all values of A. This enables the author in §79, while attempting to generalize the addition formula, to write.

$$\sin[90° + (A' + B)] = \cos(A' + B),\ 0 < A' < 90°,\ 0 < B < 90°.$$

He then remarks since A' and B are now both less than 90° we may write

$$\cos(A' + B) = \cos A' \cos B - \sin A' \sin B.$$

(§ 76).

There is certainly a flaw in the general accuracy of the argument up to this, the pivotal point of trigonometric analysis, for § 76 does not completely justify this expansion, since the demonstration to which reference is made depends upon a figure representing both A' and B, as in the first quadrant, and their sum also as in the first quadrant, whereas, in the case before us, we have no means of knowing whether $A' + B$ is greater or less than ninety degrees. In fact, before analytic demonstrations for particular cases can be accurately defended, geometric demonstrations must be given for $0° < A < 90°$, $0° < B < 90°$ for the four possible cases under this head, namely,

$$(A + B) < 90°,\quad (A + B) > 90°,\quad (A - B) > 0°,\quad (A - B) < 0°.$$

On the other hand, it must be admitted that the author, in paragraph seventy-eight, calls attention to the fact that a similar construction will apply to all possible cases, and even gives a third example, different from either, of those that are necessary. The criticism is, however, that, since up to this point unusual effort has been made to demonstrate the addition theorems, this is certainly not a good place to leave necessary steps to the student.

Like most English text-books, the present